

6. PLANNING AND DESIGN CRITERIA

6.1 General

The purpose of the planning and design criteria is to establish a common basis for the subsequent comparison of technical alternatives, in addition to establishing the target performance criteria for the planned water supply improvements. The relevant criteria include peaking factors applied to average daily demands, water treatment requirements, and unit costs of construction by type of facility (pipes, pump stations, and reservoirs). Details related to economic analysis of alternatives (useful life, discount rate, O&M costs) have been used in a generalized analysis for economical velocities in force mains. More detailed technical criteria, such as those embodied in WAJ standards and in the technical specifications of bid documents, are implicit but are not germane to the present discussion. The criteria and methodology for their application are described in this section.

6.2 Design for Continuous Supply

The planning criteria for the transmission system (the subject of this study) are relatively simple compared to those for the WLRP (the on-going Water Loss Reduction Program). Under the WLRP, the design objective is to deliver peak-hour demands through local distribution networks, with sufficient pipe capacity to maintain a minimum head of 20m anywhere within the local network under peak-hour conditions. The reservoir water level must also be chosen to keep the maximum static head in the local network at less than 50m to minimize leakage losses; in areas of steep topography, the maximum head may be allowed to increase to about 100m to have a practical width of service area within each pressure zone. For the transmission system, the major criterion is much simpler: to deliver the required supply to a local WLRP distribution reservoir at a constant rate during the day of maximum demand (the maximum daily demand) in a given design year.

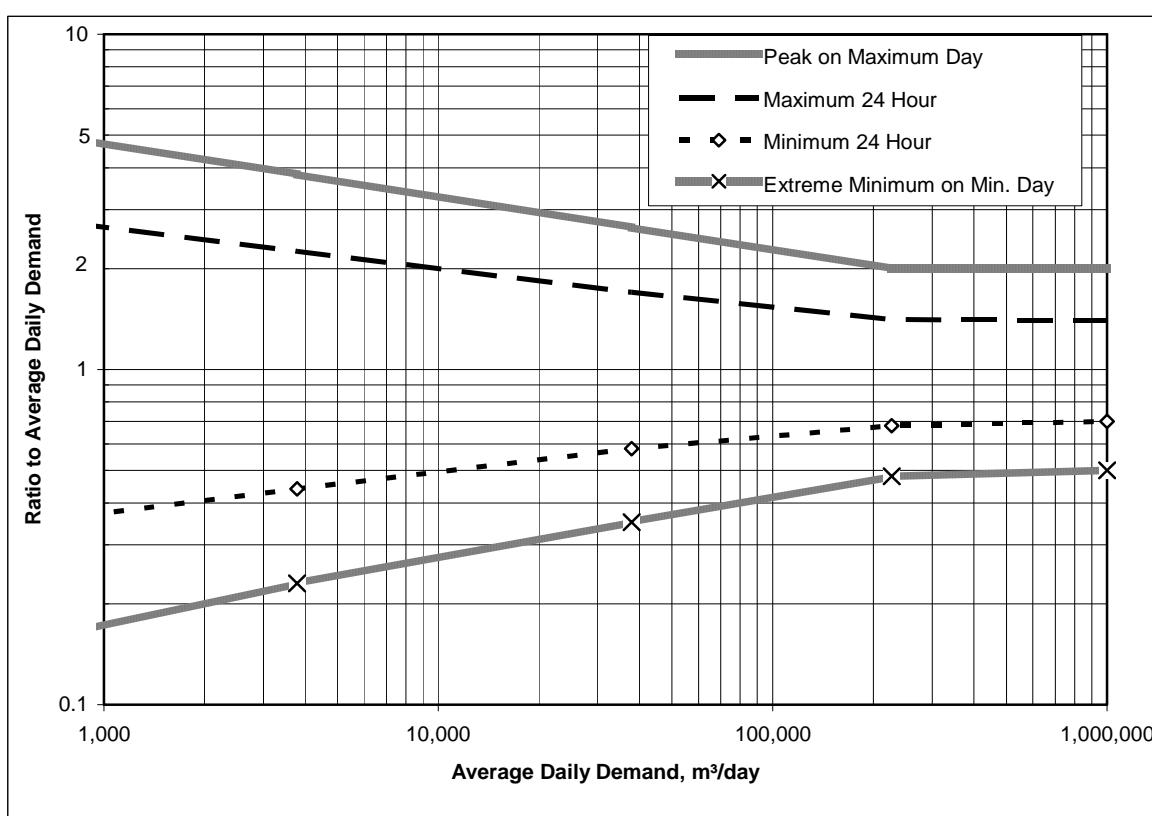
For this transmission study, the design horizon is 2030, with phased expansion in development of water sources and transmission improvements over this period. The WLRP is using design years of 2015 and 2025. The WLRP is providing to this study the relevant information for each of 101 local distribution reservoirs: the total water demand for the distribution districts served by the reservoir, as forecasted in the years 2015 and 2025; the ground elevation of the reservoir; the boundaries of the distribution districts served by the reservoir; and the local wells that provide a portion of the supply to the area. For the demand forecast developed in Section 4 of this report, the total supply to be delivered in the year 2030 is essentially the same as the WLRP forecast for the year 2025, and hence the transmission system under this study can be designed for the same flows used in the design of the distribution networks under the WLRP. In any case, as previously noted, the most important use of the supply/demand projections will be to track the increase in demand and bring new supplies on in time to satisfy them.

The transmission system is to be designed to carry the maximum daily demand to each local reservoir. The design factor of interest is the "maximum daily demand factor" or MDDF, defined as the ratio of maximum-daily to average-daily demand in a given design year. Under the existing system of rationing water, there is very limited data in Jordan on the appropriate value for MDDF. In the Amman distribution system, rehabilitation and restructuring has progressed to the point where about 12% of the customers receive continuous supply; it has been reported verbally that the summer-time daily demand is about 33% greater than the average demand, or MDDF = 1.33. However, Amman has a large

influx of visitors during the summer, which accentuates the peak demand, and the 12% sample may not be representative.

Experience data in the USA is summarized in Figure 6-1, which shows the various peaking factors that apply to the flow variations within a year: the factors for peak hour, maximum day, average day, minimum day and minimum hour, as a function of the average daily flow. For a water system having an average daily demand of 200,000 m³/day or greater, the peaking factor for maximum daily demand is about 1.40. However, this is considered relatively high for application to Jordan, because the demands in the USA commonly include a relatively large component for watering of lawns and other vegetation during the summer. This is not expected to occur in Jordan, in part because water prices are expected to remain high, and also because lawn and garden areas tend to be relatively smaller.

Figure 6-1 Ratios of Extremes to Average Daily Flow



We propose that a somewhat lower MDDF of 1.2 be adopted for the NGWA system, based on the following considerations:

- A high value of MDDF would allow NGWA to accentuate the existing seasonal fluctuations in groundwater level in the aquifers, and might reduce or dry up the flow from springs in portions of the uplands.
- A high value of MDDF might require major modifications to existing well fields and transmission systems, which should be avoided in the near term, when the principal objective is to overcome basic resource and capacity constraints.
- The NGWA service area does not have as large an influx of visitors during the summer as Amman, and the high price of water should result in a relatively constant water demand to meet only the essential water needs of customers.

- Future experience may show that a higher value of MDDF is in fact needed for continuous supply, but this should be accommodated later in the 25-year planning period - after the NGWA system has been rehabilitated and restructured, and after experience in continuous supply has validated the need - in order to make the system improvements more affordable in the near term.
- It is to be hoped that local wells within the service areas of the local distribution reservoirs could operate seasonally to meet the maximum daily demands; NGWA has a large number of wells that are not operated that could perhaps be rebuilt or rehabilitated to meet the maximum daily demand. This would minimize the effect of high MDDF on the design of the transmission system.

The resulting year-2030 maximum daily demands on the local distribution reservoirs are presented in section 7 of this report, which deals with the conceptual design of the year-2030 transmission system.

6.3 Design for Intermittent Supply

Under the WLRP, the service area of local distribution reservoirs is divided into several districts, with water to be rationed to each district on 3 days of each week. Service from a given reservoir would be rotated among the districts. As a result, the pipe from the reservoir to a single district might have to be designed for a peaking factor of (7/3) or 2.33 times the average daily demand of the district.

However, the supply required from the transmission system would have a lower peaking factor, depending upon the number of districts and whether the districts are of equal size. A single reservoir supplying two equal-sized districts would reduce the required flow from the transmission system to only (7/6) of the average flow, for a peaking factor of only 1.17. We believe that in most situations requiring a rationed supply, the peak demand can be accommodated within the proposed MDDF of 1.2. If the system is resource-constrained, then the per-capita flows to be rationed will be lower than the target consumption adopted for continuous supply, and the transmission capacity at 1.2 MDDF should be sufficient regardless of the number of rationing districts or their relative size. If not, in such cases NGWA could modify the local piping or install additional valves to create additional rationing zones of more-equal size, rather than building long high-cost transmission pipelines from the water source to the local reservoir.

6.4 Water Treatment Requirements

Treatment requirements have been studied under this project by assessment of the raw water quality, and the treatment processing required to achieve the Jordanian standards for drinking water; these have been supplemented by the current MOUs that exists between WAJ and the Ministry of Public Health. Our preliminary assessment of the water treatment process requirements is presented in Appendix G, for the two treatment plants under consideration: the King Abdullah Canal 500 m³/hour source, and the Al Wehdeh Dam source. Three alternative process trains have been considered: conventional granular filters; micro-filtration using immersed membranes; and ultra-filtration using immersed membranes. The conclusion of the study in Appendix G is that micro-filtration appears to be the most appropriate treatment process, based on estimated costs and effectiveness of treatment.

6.5 Pump Stations

It is anticipated that most of the pump stations required will be similar in nature to the existing pump stations, in which the static head is usually high compared to the friction head. The pump station in these cases would consist of 3 or 4 constant-speed pumps of equal capacity, with one standby pump. Where the flow and head may be highly variable, we will consider variable-speed pumps; these may be found advantageous, for example, in handling the variations in water level in taking water from the Al-Wehdeh Dam. As in the Wadi Al-Arab system, we would propose that pump stations be placed at intervals along a pipeline, to limit the head at any one station to about 200m; this reduces the design pressure in the pipe to commercially-available pressure classes, and provides flexibility and economy in releasing water to meet local customer demands in the vicinity of the pump stations. We would also attempt, when practicable, to standardize on the pumping heads and pumps used in each of the pump stations in series, to minimize problems in maintenance and spare parts for repairs.

6.6 Pipelines

Most of the required new pipes for the future transmission system will be relatively small, ranging at most up to about 1000mm diameter. Preference will be given to routing the pipes along roads and other public rights-of-way, although some large pipelines may require a cross-country right-of-way parallel to roadways. Above-ground pipes will be avoided to minimize tampering or susceptibility to damage, and pipes will be buried in trenches with minimum 1m of cover to avoid freezing and damage from traffic loads. In pipes up to 1000mm, the preferred pipe material is DI (ductile iron), which has been used successfully and almost exclusively in Jordan. Where exceptionally high pressures are encountered for large diameter pipes, steel pipes will be considered.

6.7 Unit Costs

The preliminary conceptual design of the future transmission system indicates that the expected improvements would include pipelines of various diameters up to 1000mm, distribution reservoirs ranging in size from 100 to 10,000 m³ and pump stations of various flows up to 4200 m³/h. Other potential facilities include water treatment plants for the Al Wehdeh new water source and at KAC close to PS0 of the Tabaqat Fahel transmission system. In the feasibility study, the costs of pipelines, pump stations and reservoirs will be built up from the unit costs developed herein. The costs of the WTPs will be estimated individually rather than from generalized unit costs.

The unit costs adopted in this report are derived from actual costs of recently-completed and on-going, WAJ projects funded by various donors, among those are USAID, KFW, EIB and the Italian Government. The unit costs developed here would represent average unit costs for the various donors funded projects who usually share funding of large water sector projects in Jordan similar to the NG project. At this stage it's not known which funding agency would fund any of the proposed projects, therefore using the average unit costs developed here would produce a total cost that is good for the purposes of this report. However, the cost of any proposed project would depend on the cost of materials in the country of origin of the donor if the project's equipment has to be imported from the donors country.

An annual escalation rate of 2% has been used to escalate the costs from the year of quotation up to the costs in year 2004. A general allowance of 10% has been added for

contingencies, and to account for the recent and rapid increase in the costs of construction materials that took place in 2003/2004.

6.7.1 Ductile Iron Pipelines Unit Costs

Data on actual bid rates for DIP was collected from the PMU/MWI, analyzed and tabulated **Table 6-1** show the projects and contracts from which DI pipeline information were taken; it also shows the year of the bid and the quoted rates in JD/m for ductile iron pipes of 100 – 1200 mm diameter.

Table 6-1 Ductile Iron Piping Actual Rates (JD)

Project	Year	Fund	Contra	UNIT RATE IN (JD/m)															
				DN 100	DN 150	DN 200	DN 250	DN 300	DN 400	DN 450	DN 500	DN 600	DN 700	DN 800	DN 900	DN 1000	DN 1100	DN 1200	
Restructuring of Amman Water System	2000	EIB	C2					70	98	115	130	165	202						
	2000	EIB	C7	29	39	50	65	75	100		140	200							
	2000	EIB	C8					90				148	282	341	406				
	2000	EIB	C9		49	59		84	117		154				347				
	2000	KFW	C10	38	46	49				104									
	2000	KFW	C10	34	40	44	53	71	95		112	138	172		247				474
	2000	Italy	C13	43	53	62	69	89	116										
	2001	USAID	C15		52	40		61	92		157		260		375				
Rehab of Wells & Springs	2000	USAID	Kafrein		78	66	110	102			270								

Three factors are taken in consideration to produce adjusted actual unit rates that would make the rates commensurate with the conditions of the NG project, those three factors are:

- The bid rates of Amman project shown in **Table 6-1** are for pipelines laid in roads where reinstatement with asphalt would be required. In the NG transmission the majority of the pipelines would be in dirt surface adjacent to the asphalt roads, where reinstatement with asphalt would not be required.
- Working in open areas like the transmission in the NG is much easier than working in Amman with all the difficulties that the Municipality would impose on the contractors. Its assumed that Amman project Contractors included cost for this factor .A reduction of 5% is assumed for this factor.
- The Amman projects were tendered over short period, contractors who won one contract increased their prices for the second contract. Its assumed that in general the rates were increased, this would not be the case in the NG. 3% decrease in the actual rates are assumed for this factor.

Table 6-2 shows the adjusted DIP unit costs in JD/m.

Table 6-2 Ductile Iron Piping Adjusted Actual Rates (JD)

Project	Year	Fund	Contra	UNIT RATE IN (JD/m)															
				DN 100	DN 150	DN 200	DN 250	DN 300	DN 400	DN 450	DN 500	DN 600	DN 700	DN 800	DN 900	DN 1000	DN 1100	DN 1200	
Restructuring of Amman Water System	2000	EIB	C2					60	86	100	115	146	180						
	2000	EIB	C7	23	32	42	56	65	87		124	178							
	2000	EIB	C8					78				131	254	308	367				
	2000	EIB	C9		41	51		73	103		136				313				
	2000	KFW	C10	31	39	41				89									
	2000	KFW	C10	28	32	36	45	61	83		98	121	152		220				425
	2000	Italy	C13	36	45	53	59	78	102										
	2001	USAID	C15		44	33		51	80		139		233		338				
Rehab of Wells & Springs	2000	USAID	Kafrein		78	66	110	102			270								

Table 6-3 show the adjusted actual costs in \$/m escalated to year 2004 prices and including contingencies. It also shows the estimated maximum, minimum and average adjusted actual unit rates.

Table 6-3 Ductile Iron Piping Year 2004 Estimated Rates (\$)

Project	Year	Fund	Contract	UNIT RATE IN (\$/m)															
				DN 100	DN 150	DN 200	DN 250	DN 300	DN 400	DN 450	DN 500	DN 600	DN 700	DN 800	DN 900	DN 1000	DN 1100	DN 1200	
Restructuring of Amman Water System	2004	EIB	C2	49	65	84	109	126	165	194	219	276	339						
	2004	EIB	C7									235	335						
	2004	EIB	C8							151				249	473	572	681		
	2004	EIB	C9						140	197			258					582	
	2004	KFW	C10	64	78	82					174								
	2004	KFW	C10	57	66	73	89	119	160			187	231	288			414		
	2004	Italy	C13	72	88	104	115	149	195									795	
Rehab of Wells & Springs	2004	USAID	C15						100	151			259		428		617		
	2004	USAID	Kafrein			131	110	185	171			453							
All Projects	2004		min	49	65	66	89	100	151	174	187	231	288	428	414	617	795		
	2004		average	61	85	88	125	134	172	184	225	300	367	500	559	617	795		
	2004		max	72	131	110	185	171	197	194	258	453	473	572	681	617	795		

Note: 2% yearly escalation rate is used to calculate year 2004 unit rates. Also 10% is adopted for contingencies and construction materials price increase in 2004

Figure 6-2 shows the trend line of unit price as a function of DI pipe diameter, and a comparison with the unit prices used in the WLRP conceptual design report.

Figure 6-2 Ductile Iron Pipes, Year 2004 Estimated Rates (\$)

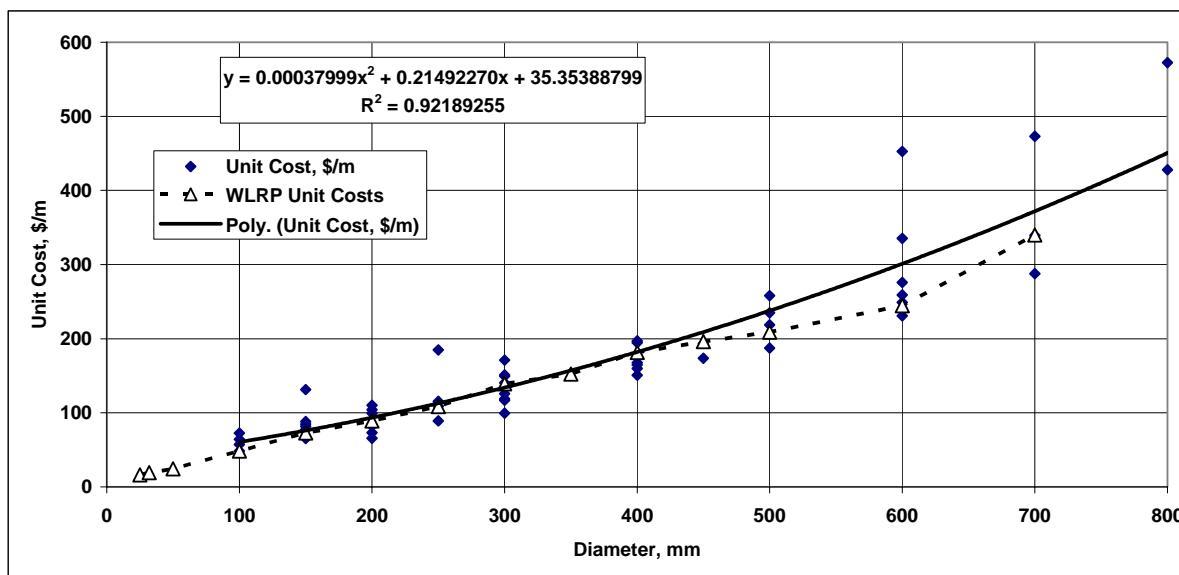


Table 6-4 show the derived DIP unit costs used in estimating the costs in this report in \$/m rounded up to one dollar.

Table 6-4 Ductile Iron Piping Year 2004 Estimated Rates By Diameter (\$/m)

DIP	DN 100	DN 150	DN 200	DN 250	DN 300	DN 400	DN 450	DN 500	DN 600	DN 700	DN 800	DN 900	DN 1000	DN 1100	DN 1200
Unit Rate, \$/m	61	76	94	113	134	182	209	238	301	372	450	537	617	706	795

6.7.2 Reservoirs Unit Costs

Similar to the data on DIP, data on the actual costs of the reservoirs were collected from the PMU/MWI analyzed and tabulated. **Table 6-5** shows the projects and contracts where information on the costs of reservoirs were taken; it also shows the year of the bid and the quoted reservoir's total cost in JD for various reservoir volumes.

Table 6-5 Reservoirs Actual Costs (JD)

Project	Year	Contract	Name	COST IN (JD)								
				m ³ 500	m ³ 1000	m ³ 2000	m ³ 4000	m ³ 5000	m ³ 6000	m ³ 8000	m ³ 10000	m ³ 12000
Restructuring of Amman Water System	2000	C2	Hashimi				282679					
	2000	C2	Sahab 1				265818					
	2000	C2	Sahab 2				265818					
	2000	C8	Qweismeh									800813
	2000	C9	Safut U.		201000							
	2000	C9	Safut L.		263000							
	2000	C9	S. Badran U.		411000							
	2000	C9	S. Badran L., Kamalia, U. El Shjayrat, Khilda, Sweileh		127000	466000	405000	697000				579000
	2001	C15	Average of several		250851							
	2001	C15	Na'ur-U., Tarek, W. Esseer-U., W. Esseer-L, Marj West, Yadoudeh, Yasminn		289705	446898	620681					
	2001	C15	Zara Main		432901	788329	690000					
Zara Mai'n	2004	Zara Main				586158	1316828	1089724				
Rehabilitation of Priority Wells & Springs	2000	Kafrein	Kafrein WTP	61866	188360							

The factors taken in consideration for adjusting the actual unit costs of the DIP are not applicable to the reservoirs actual costs. Accordingly, the actual unit costs presented in **Table 6-5** were not adjusted. **Table 6-6** show the estimated costs of reservoirs updated to year 2004 in \$ as derived from the information presented in **Table 6-5**. It also shows the estimated maximum, minimum and average costs for a given reservoir volume.

Table 6-6 Reservoirs Year 2004 Estimated Costs (\$)

Project	Year	Contract	Name	COST IN (\$)								
				m ³ 500	m ³ 1000	m ³ 2000	m ³ 4000	m ³ 5000	m ³ 6000	m ³ 8000	m ³ 10000	m ³ 12000
Restructuring of Amman Water System	2004	C2	Hashimi				474055					
	2004	C2	Sahab 1				445778					
	2004	C2	Sahab 2				445778					
	2004	C8	Qweismeh									1342970
	2004	C9	Safut U.		337079							
	2004	C9	Safut L.		441053							
	2004	C9	S. Badran U.		689250							
	2004	C9	S. Badran L., Kamalia, U. El Shjayrat, Khilda, Sweileh		212980	781486	679188	1168874				970987
	2004	C15	Average of several		420678							
	2004	C15	Na'ur-U., Tarek, W. Esseer-U., W. Esseer-L, Marj West, Yadoudeh, Yasminn		485838	749452	1040887					
	2004	C15	Zara Main		725978	1322034	1157135					
Zara Mai'n	2004	Zara Main				926295	2080959	1722071				
Rehabilitation of Priority Wells & Springs	2004	Kafrein	Kafrein WTP	103749	315881							
All Projects	2004	min		103749	212980	315881	445778	926295	679188	1168874	1157135	970987
	2004	average		103749	420208	400860	603754	926295	1014036	1624917	1439603	1156979
	2004	max		103749	689250	485838	781486	926295	1322034	2080959	1722071	1342970

Note: 2% yearly escalation rate is used to calculate year 2004 costs. Also 10% is adopted for contingencies and construction materials price increase in 2004

Figure 6-3 shows the trend line of reservoir costs as a function of reservoir volume, and a comparison with the WLRP estimated costs for reservoirs.

Figure 6-3 Reservoirs: Year 2004 Estimated Costs (\$)

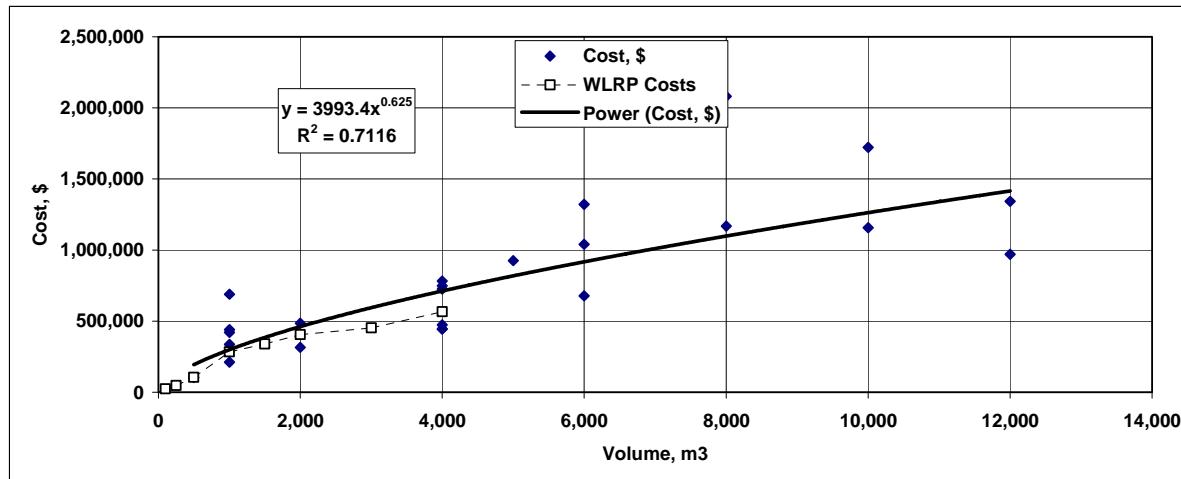


Table 6-7 show the derived reservoirs unit costs used in estimating the costs in this report in \$ for a given reservoir volume.

Table 6-7 Reservoirs Year 2004 Estimated Costs By Reservoir Volume (\$)

Reservoir Volume m³	100	150	250	500	1000	1500	2000	3000	4000
Cost in \$	71,014	91,496	125,909	194,178	299,463	385,833	461,835	595,036	712,246
Reservoir Volume m³	5000	6000	7000	8000	9000	10000	11000	12000	13000
Cost in \$	818,840	917,672	1,010,483	1,098,434	1,182,345	1,262,824	1,340,335	1,415,243	1,487,844

6.7.3 Pump Stations Unit Costs

Table 6-8 show the projects and contracts where information on pump station costs were obtained, the year of the bid and the quoted pump station total cost in JD.

Table 6-8 Pump Stations Actual Costs (JD)

Project	Year	Contract	Name	Cost, JD				
				m³/h 450	m³/h 1875	m³/h 2000	m³/h 3300	m³/h 5400
Restructuring of Amman Water System	2000	C2	Ain Gazal PS					1814431
		C2	Marka Tower PS	143423				
		C8	Nasr PS				436746	
		C8	Hizam PS				439992	
		C9	Dabouq PS			644000		
		C9	Daheyat El Rasheed P.S.	251000				
		C9	S. Badran U. Booster					
		C9	S. Badran L. Booster					
Zara Mai'n	2004	Zara Main	Raw Water PS					
		Zara Main	PS1				2508681	
		Zara Main	PS2				2379608	
		Zara Main	PS3				2450941	
		Zara Main	PS4				2295649	
		Zara Main	PS5				2441109	

Table 6-9 shows the estimated costs of pump stations updated to year 2004 in \$ derived from the information presented in **Table 6-8**. It also shows the estimated maximum, minimum and average costs for the pump stations of a given flow rate.

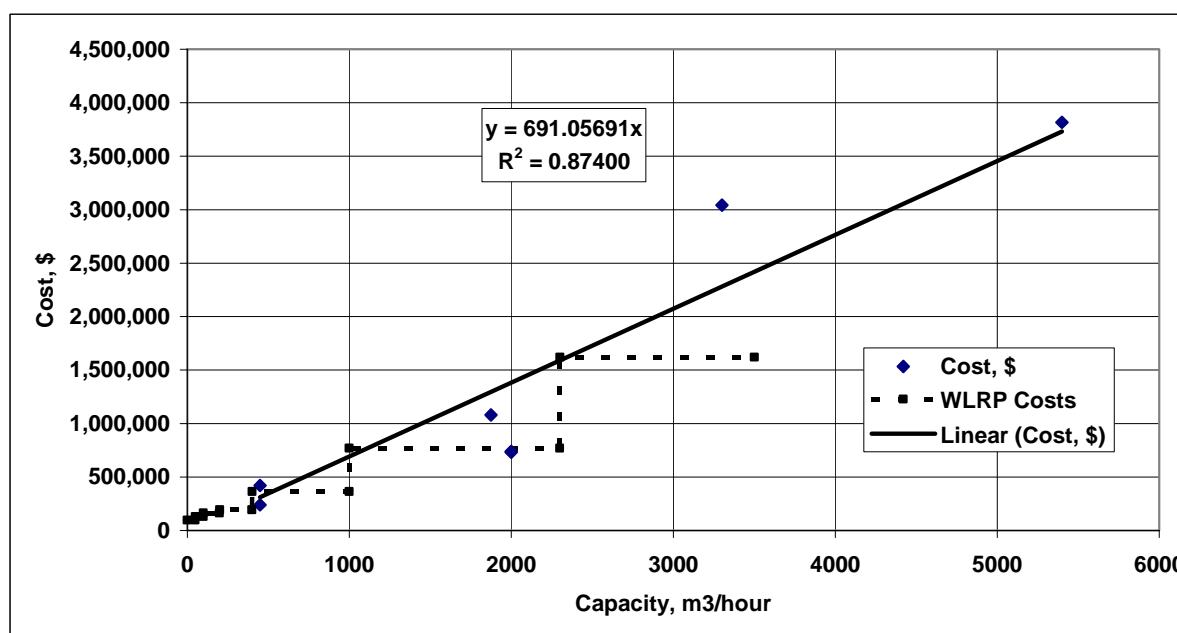
Table 6-9 Pump Stations Year 2004 Estimated Costs (\$)

Project	Year	Contract	Name	Cost, \$				
				m ³ /h 450	m ³ /h 1875	m ³ /h 2000	m ³ /h 3300	m ³ /h 5400
Restructuring of Amman Water System	2004	C2	Ain Gazal PS				3042815	
	2004	C2	Marka Tower PS	240521				
	2004	C8	Nasr PS			732426		
	2004	C8	Hizam PS			737870		
	2004	C9	Dabouq PS		1079993			
	2004	C9	Daheyat El Rasheed P.S.	420929				
	2004	C9	S. Badran U. Booster					
	2004	C9	S. Badran L. Booster					
		Zara Main	Raw Water PS					
Zara Mai'n	2004	Zara Main	PS1				3964422	
	2004	Zara Main	PS2				3760451	
	2004	Zara Main	PS3				3873178	
	2004	Zara Main	PS4				3627773	
	2004	Zara Main	PS5				3857639	
All Projects	2004	min	min	240521	1079993	732426	3042815	3627773
	2004	average	average	330725	1079993	735148	3042815	3816693
	2004	max	max	420929	1079993	737870	3042815	3964422

Note: 2% yearly escalation rate is used to calculate year 2004 costs. Also 10% is adopted for contingencies a construction materials price increase in 2004

Figure 6-4 shows the trend line in cost of pump stations as a function of flow rate.

Figure 6-4 Pump Stations: Year 2004 Estimated Costs (\$)



6.8 Basis for Economic Cost Comparisons

The cost of pipelines is expected to dominate among the components of capital cost for the future transmission system, while the cost of power is expected to dominate among the components of annual costs for operation and maintenance. The “economical velocity” or optimal pipe size, that provides the best balance between pipe cost and power cost for a given design flow, has been analyzed. The derivation and results are shown in **Appendix E**, and energy-management aspects are discussed in **Appendix F**. The parameters adopted for this generalized cost comparison include the following:

Interest rate:	6%
Useful life, DI pipe	50 years
Present-worth factor	16.7076
Price of electricity	62 fils/kWh
Pump efficiency	75%
Peaking factor	1.2 maximum daily/annual average
Duty pumps	1, plus 1 standby pump
C-value	110 in Hazen-Williams pipe friction formula

Preliminary results, obtained by using this selection of parameters, are shown below in **Section 6.10**.

6.9 Capacities and Reliability of Wells and Springs

The pipe sizes in the transmission system have been determined based on two design conditions:

- Under maximum-daily demands in 2030, all wells would be operating at capacity throughout the day. This is to assure that the pipe sizes are adequate to carry the full capacity of the wells.
- Under average-daily demands in 2030, the largest local well supplying a distribution reservoir could be out of service, and the resulting deficit in supply would be made up by flows from the transmission system. The pipe connecting the distribution reservoir to the transmission system would be enlarged if necessary to satisfy this emergency condition.

The wells, springs and surface-water sources in the NGWA service area have been combined into 91 “well fields”, for which the assumed capacities in 2030 are listed in **Table 6-10**. Some of the well fields contain more than one well or other water source. The capacities of 207 individual wells, springs or surface water sources have been considered, which have been summed together to obtain the well-field totals in **Table 6-10**. The individual sources and their assumed capacities in 2030 are listed in **Table 6-11**.

Table 6-10 Assumed Capacities of Well Fields in 2030

WF ID	Well Field	Total No. of Wells	Capacity, m3/hr	Weighted GW Elev	Reservoir Served	Reservoir Elev.	Static Head, m	KW	Energy, kwh/m3
1	Hodoud Jaber	1	62	470.6	ZA03MA-2	660	189.5	58.2	0.94
2	Koum Al Ahmer	2	99	485.0	ZA02MA-1	780	295.0	144.0	1.46
3	Shawahed	2	80	436.8	JE09JE-1	645	208.2	82.5	1.03
4	Tayybeh	1	26	53.9	DS04IR-1	365	311.1	40.1	1.54
5	Toura	2	54	371.6	RA04RA-1	480	108.4	29.0	0.54
6	Zubaideyeh	1	46	478.1	ZA03MA-1	685	206.9	46.8	1.03
7	Bushra	2	87	157.5	ZE06IR-1	580	422.5	183.2	2.09
8	Dagmaseh	1	20	526.9	UL08MA-1	860	333.1	33.0	1.65
9	Debbein	1	20	675.9	ZE47JE-1	860	184.1	18.2	0.91
10	Dougara	1	25	8.0	ZE05IR-1	435	427.0	52.9	2.12
11	Hakama	5	134	163.9	ZE06IR-1	580	416.1	275.6	2.06
12	Halawa	1	88	32.9	ZE58AJ-1	700	667.1	290.9	3.31
13	Rhab	1	30	527.1	UL10MA-1	905	377.9	56.2	1.87
13	Rhab		0.0		UL10MA-2	925	925.0		
14	Jaber	8	360	231.1	RA02RA-1	560	328.9	586.6	1.63
15	Juhfiyya	2	190	515.7	ZE20IR-1	780	264.3	248.2	1.31
16	Kufr Youba	1	32	291.9	ZE20IR-1	780	488.1	78.0	2.42
17	Mahasi	2	88	332.9	RA02RA-1	560	227.1	99.4	1.13
18	No'aymeh	3	75	553.6	ZE26IR-1	790	236.4	87.6	1.17
18	No'aymeh		0.0		ZE27IR-1	910	910.0		
19	Oyon Al Hamam	3	361	157.3	DS08AK-1	380	222.7	398.7	1.10
20	Rahoub	1	32	162.6	ZE07IR-1	560	397.4	63.5	1.97
21	Safsafa	1	24	302.4	ZE54JE-1	780	477.6	56.8	2.37
22	Souf	2	44	841.5	ZE43JE-1	1010	168.5	36.7	0.84
23	Sumaya	10	418	455.0	ZA05MA-1	750	295.0	611.3	1.46
24	Um Es Serb	1	20	426.3	LOCAL				
25	Zniyya	4	232	454.1	UL13MA-1	780	325.9	374.3	1.61
25	Zniyya		0.0		UL14MA-1	720	720.0	0.0	0.00
25	Zniyya		0.0		UL15MA-1	675	675.0	0.0	0.00
26	Zuqage	2	159	-54.4	ZE58AJ-1	700	754.4	592.8	3.74
36	Aqeb	33	2677	515.8	Mafraq City	gravity	180.7	2395.8	0.90
37	Arjan	1	0	0.0	LOCAL				
38	Bajj	1	0	0.0	LOCAL				
39	Beit Idis	1	45	140.2	LOCAL				
42	Daba'an	1	0	0.0	LOCAL				
43	Fo'ara	1	17	68.7	LOCAL				
45	Harara	1	45	518.2	LOCAL				
46	Harima	3	117	86.9	LOCAL				
47	Hodoud PS	1	32	262.7	RA02RA-1	560	297.3	47.1	1.47
48	Jaber El Sarhan	2	0	0.0	LOCAL				
50	Judyla	2	135	197.5	LOCAL				
51	Khasha El Salteen	1	0	0.0	LOCAL				
52	Krayymeh	6	110	-234.8	LOCAL				
53	Kufr Khal	1	0	0.0	LOCAL				
54	Maghasel	1	0	0.0	LOCAL				
55	Majar	2	34	401.0	LOCAL				
56	Malka	1	0	0.0	LOCAL				
57	Manshiyah	2	100	-26.0	Wadi Al Arab WTP	10	36.0	17.8	0.18
58	Mashare	1	60	-278.9	LOCAL				
59	Mukeifteh	3	123	0.0	LOCAL				
60	Mukhaiba	1	0	0.0	LOCAL				
61	Nahda	1	0	0.0	LOCAL				
62	Oairawan	1	98	572.0	LOCAL				
63	Qantara	1	63	700.0	LOCAL				
64	Rafayyat	1	45	0.0	LOCAL				
65	Rawdah Ameera Basma	1	100	0.0	LOCAL				
66	Rawdat Bany Hashem	1	0	0.0	LOCAL				
67	Rayashi	1	45	421.0	LOCAL				
68	Sabha	1	50	0.0	LOCAL				
70	Saham	1	0	0.0	LOCAL				
72	Shajara	1	0	0.0	LOCAL				
73	Slechat	3	85	-153.6	LOCAL				
74	Spairah	1	84	-51.3	LOCAL				
75	Suwelmeh	4	137	392.8	LOCAL				
76	Tabaqat Fahel	8	993	-45.4	Wadi Al Arab PS0	gravity	0	0	
77	Talat Aruz	1	20	0.0	LOCAL				
78	Um Al Jemal	3	143	491.8	Zatary PS	700	208.2	147.5	1.03
79	Um Mrara	1	34	574.0	LOCAL				
80	Wadi Al Arab	9	2345	-15.1	Wadi Al Arab WTP	10	25.1	291.6	0.12
81	Wadi Ed Dear	1	52	590.0	LOCAL				
82	Waqqas	1	17	-252.0	LOCAL				
83	Zamlah	1	52	517.1	Zatary PS	700	182.9	47.2	0.91
84	Zatary	5	361	353.9	Zatary PS	700	346.1	619.2	1.71
85	Corridor	8	1180	407.4	Zatary PS	700	292.6	1710.7	1.45
86	Al Wehdeh Dam,MaxDay	1	4110	0.0	W PS1	260	260.0	5293.9	1.29
87	Remaining Springs	7	198	600.0	LOCAL				
88	JV salty springs	4	457	-100.0	Wadi Al Arab PS0	10	110.0	248.9	0.55
89	Imports, Balqa & Zarqa		46		LOCAL				
90	future local wells		685	0.0	LOCAL				
91	KAC WTP		600						
Totals, Averages		195	18300				15364	0.84	

Table 6-11 Individual Water Sources and Their Assumed Capacities in 2030

Seq	WF ID	Well Field	Facility ID	Facility Name	MWI ID	Status	ROU	Contour Elev, m	Capacity nm3/hr	Dynamic Depth, m	Depth m	X	Y	Static Depth, m	Installed	Static Elev, m	Dynamic Elev, m	Q* Hdyn
1	1	Hodoud Jaber	204-1	Al Hudud Jaber Well No.7	AD3004	1	8	600.0	62	129.45	275	261977	213941	126	1993-03-13	474.0	470.55	29174
2	2	Koum Al Ahmer	243-1	AL Kum Al Ahmer PS	AL3132	1	8	744.3	49	243.3	445	282051	197213	238	1998-05-07	506.3	501.0	24319
3	2	Koum Al Ahmer	246-1	AL Kum Al Ahmer New Well	AL3564	1	8	750.0	50	280.6	497	282713	197501	260	2000-07-13	490.0	469.4	23470
4	3	Shawahed	151-1	AL Shawahed Al Shargi Wells	AL2716	1	7	633.1	54	74.25	131	234345	190122	32	1979-08-13	504.9	436.8	23585
5	3	Shawahed	152-1	AL Shawahed Al Gharbi Well	AL2717	1	7	631.9	26	195.1	346	234042	190234	127	1992-04-20	504.9	436.8	11356
6	4	Tayybeh	43-1	Al Tayybeh PS	AB1174	1	5	359.5	26	305.6	443	216554	218200	263	1988-06-26	96.5	53.9	1401
7	5	Qairawan	86-1	Al Toura Well 3	AD3045	1	11	440.1	19	148.3	297	244516	229753	17	1999-07-17	423.1	291.8	5544
8	5	Toura	87-1	Al Toura PS Well 1	AD3008	1	11	450.0	35	35	350	244542	227933	25	1994-01-02	425.0	415.0	14525
9	6	Zubaideyeh	220-1	AL Zubaideyeh Well	AD3056	1	8	678.2	46	200.1	261	271645	198634	196	2000-04-28	482.2	478.1	21847
10	7	Bushra	53-1	Bushra PS Well 3	AD1268	1	5	530.0	45	374.85	602	234107	220872	371	1990-06-27	159.0	155.2	6982
11	7	Bushra	53-2	Bushra PS Well 4	AD3002	1	5	530.0	42	370.02	614	234107	220877	368	1995-06-11	162.0	160.0	6798
12	8	Daqmaseh	181-3	Daqmaseh PS	AL3382	1	8	739.3	20	212.4	367	243634	190564	55	1996-01-24	684.3	526.9	10537
13	9	Debbein	179-1	Debbein Well	AL3548	1	7	767.8	20	91.9	215	226689	182719	58.9	2000-08-25	708.9	675.9	13519
14	10	Doubara	37-1	Doubara PS	AE1016	1	5	330.0	25	322	370	219187	223786	320	1990-09-10	10.0	8.0	200
15	11	Hakama	55-1	Hakama Well 8	AD3037	1	5	521.4	35	Hakama	554	235087	221496		1998-01-01	172.6	162.6	5691
16	11	Hakama	51-1	Hakama Well 6	AD3018	1	5	534.7	45	372.65	485	233468	220371	367	1996-07-11	167.7	162.1	7357
17	11	Hakama	56-1	Hakama Well 5	AD3015	1	5	530.0	53	363.8	571	235255	219443	354	1996-02-06	176.0	166.2	8853
18	11	Hakama	50-1	Hakama Well 7	AD3036	2	5	529.0	0	370.25	546	234638	221214	364	1997-07-01	165.0	158.7	0
19	11	Hakama	325-1	Hakama Observation Well	AE3004	2	5	560.0	0	Hakama	0	234354	222244		2002-05-17	172.6	162.6	0
20	12	Halawa	111-1	Halawa Well 2	AB3152	1	1	257.8	88	224.9	520	210261	198959	216	2000-03-08	41.8	32.9	2894
21	13	Rhab	320-1	Irhab well (Hamamat Al Amoush)	AL3660	1	8	814.0	30	286.9	338	248534	192332	116.7	2002-06-16	697.3	527.1	15814
22	14	Jaber	95-1	Jaber Well 5	AD3025	1	11	521.9	50	297.63	589	248548	218720	259	1997-04-09	262.9	224.3	11216
23	14	Jaber	96-1	Jaber Well 4	AD3024	1	11	534.0	50	282.6	450	249296	218684	282	1997-04-05	252.0	251.4	12570
24	14	Jaber	99-1	Jaber Well 2	AD3022	1	11	559.9	40	318.18	465	250216	216194	313	1996-12-07	246.9	241.8	9674
25	14	Jaber	100-1	Jaber Well 6	AD3047	1	11	570.0	41	359.92	550	250399	215097	302	1999-09-18	268.0	210.1	8613
26	14	Jaber	101-1	Jaber PS 1 well 1	AD3021	1	11	562.9	45	336.2	551	249636	213305	290	1997-01-30	272.9	226.7	10202
27	14	Jaber	102-1	Jaber Well 7	AD3044	1	11	575.5	49	349.53	502	250368	213084	314	1999-09-06	261.5	225.9	11071
28	14	Jaber	103-1	Jaber Well 3	AD3023	1	11	589.2	45	353.2	680	250717	212374	287	1998-07-11	302.2	236.0	10620
29	14	Jaber	327-1	Jaber Observation Well (No 8)	AD3058	1	11	536.5	40	Jaber	450	248070	214607		NA	241.0	231.0	9240
30	15	Juhfiyya	62-2	Juhfiyya PS Well 1	AB1375	1	5	640.0	100	124.3	300	226819	210642	124	1986-10-12	516.0	515.7	51570
31	15	Juhfiyya	62-4	Juhfiyya PS Well 1A	AB1441	1	5	640.0	90	124.39	223	226824	210637	124	1997-04-29	516.0	515.6	46159
32	16	Kufr Youba	46-1	Kufr Youba PS	AE1001	1	5	480.0	32	188.11	287	224315	215498	160	1980-11-16	320.0	291.9	9419
33	17	Mahasi	90-1	Mahasi PS Well 5	AD1296	1	11	470.0	50	23.36	104	243601	221565	7	1988-01-16	463.0	446.6	22332
34	17	Mahasi	90-2	Mahasi PS Well 6	AD1295	1	11	470.0	38	285.52	702	243601	221570	283	1988-06-07	187.0	184.5	7067
35	18	No'aymeh	69-1	No'aymeh Pump Station 2(well 3)	AD3011	1	4	699.3	25	300.95	435	237583	203615	226	1995-04-16	473.3	398.3	9958
36	18	No'aymeh	70-1	No'aymeh Pump Station 1	AD1219	1	4	720.0	24	164.7	196	235531	203529	158	1980-06-18	562.0	555.3	13198
37	18	No'aymeh	71-1	No'aymeh Well 2	AD1220	1	4	701.3	26	337	236128	203319	193	1978-10-16	508.3	701.3	18234	
38	19	Oyoon Al Hamam	74-1	Oyoon Al Hammam Well 2	AF1002	1	2	194.5	141	40.4	284	215577	213063	29	1983-05-14	165.5	154.1	21789
39	19	Oyoon Al Hamam	75-2	Oyoon Al Hammam PS Well1	AF1001	1	2	200.0	150	39.79	226	216209	212707	33	1983-03-31	167.0	160.2	24032
40	19	Oyoon Al Hamam	323-1	Oyoon Al Hammam Well 4 (4A)	AF1003	4	2	180.0	70	Oyoon	0	215277	213332		NA	167.6	157.6	11032
41	20	Rahoub	48-1	Rahoub PS	AD0536	1	5	425.4	32	Hakama	0	237665	224206		NA	172.6	162.6	5242
42	21	Safsafa	177-1	Safsafa Well 2	AK1016	1	1	704.9	24	402.5	589	221474	183819	109	1999-05-03	595.9	302.4	7257
43	22	Souf	142-1	Souf Al Gharbi PS Well west	AL1429	1	7	980.0	40	100	120	227585	192013	56	1981-05-13	924.0	880.0	35356
44	22	Souf	143-1	Souf Esh Sharqi Well east	AL2358	1	7	960.0	4	Shawahed	135	227974	191657		NA	544.0	436.0	1665

Seq	WF ID	Well Field	Facility ID	Facility Name	MWI ID	Status	ROU	Contour Elev, m	Capacity nm3/hr	Dynamic Depth, m	Depth m	X	Y	Static Depth, m	Installed	Static Elev, m	Dynamic Elev, m	Q* Hdyn
45	23	Sumaya	210-1	Sumaya Well 12	AD3057	1	8	600.0	57	157.45	310	265890	206474	146	2000-04-08	454.0	442.6	25382
46	23	Sumaya	211-1	Sumaya Well 7	AD1125	1	8	591.8	30	117.16	382	265946	207468	115	1977-04-18	476.8	474.6	14238
47	23	Sumaya	212-1	Sumaya Well 6	AD1124	1	8	590.0	50	117.88	0	265991	207711	114	1976-06-25	476.0	472.1	23606
48	23	Sumaya	213-1	Sumaya Well 5	AD1123	1	8	590.0	42	118.5	215	266341	207753	111	1975-06-21	479.0	471.5	19879
49	23	Sumaya	215-1	Sumaya Well 11	AD1278	1	8	593.4	30	170.77	443	266652	206787	134	1991-05-21	459.4	422.6	12677
50	23	Sumaya	216-1	Sumaya Well 4	AD1122	1	8	593.5	45	190	249	266784	207309	155	1975-06-30	438.5	403.5	18343
51	23	Sumaya	217-1	Sumaya Well 9	AD1127	1	8	600.9	35	134.1	377	267553	207705	121	1969-10-01	479.9	466.8	16416
52	23	Sumaya	218-1	Sumaya Well 8	AD1126	1	8	600.4	58	120.08	390	267555	207091	114	1969-06-01	486.4	480.4	27912
53	23	Sumaya	328-1	Sumaya 3a	AD3067	1	8	594.9	70	Sumaya	0	264435	207283	NA	465.0	455.0	31850	
54	23	Sumaya	214-1	Sumaya Well 3	AD1121	2	8	590.0	0	115.85	248	266430	207282	114	1971-06-28	476.0	474.2	0
55	24	Um Es Serb	234-1	Um Es Serb PS	AD3005	1	8	660.0	20	233.7	451	274497	203257	178	1991-12-21	482.0	426.3	8526
56	25	Zniyya	193-1	Znaieh PS	AL2415	1	8	623.2	50	168.7	354	254538	180871	131	1989-09-19	492.2	454.5	22726
57	25	Zniyya	196-1	Znaieh Well 3	AL3483	1	8	580.0	112	87.5	292	258261	179700	86	1998-04-17	494.0	492.5	55078
58	25	Zniyya	197-1	Znaieh Well 4	AL3484	1	8	600.0	20	188.8	300	258342	180957	103	1998-04-17	497.0	411.2	8224
59	25	Zniyya	200-1	Znaieh Well 5	AL3485	1	8	590.2	50	205.2	300	258785	180183	97	1996-06-22	493.2	385.0	19250
60	26	Zuqaq	106-1	Zuqaq Well 1	AH3003	1	1	120.0	55	339.1	450	210112	200414	3	2001-03-04	117.0	-219.1	-12051
196	26	Zuqaq	107-1	Zuqaq Station 1	AJ0580	1	1	120.0	104	Halawa	0	210185	200357	NA	43.0	33.0	3418	
125	28	Ain Al Saluce	127-1	Ein AL Saluce Spring	AJ0524	2	1	932.1	0	0	222706	190918	0	NA	NA	NA	NA	
118	35	Anjara	128-1	Anjara PS	AJ0528	2	1	890.6	0	0	221543	190462	0	NA	NA	NA	NA	
64	36	Aqeb	247-1	Al' Aqeb Well093-1	AL1485	1	NGWA	710.0	86	185.94	305	283554	188020	183	1979-03-19	527.0	524.1	45004
65	36	Aqeb	251-1	Al' Aqeb Well K 96-1	AL3362	1	NGWA	738.1	80	238	367	285932	187221	217	1987-05-04	521.1	500.1	40011
66	36	Aqeb	251-2	Al' Aqeb Well K 96-2	AL1193	1	NGWA	738.1	151	215	371	285932	187226	216	1986-02-22	522.1	523.1	78945
67	36	Aqeb	242-1	Al' Aqeb Well K090	AL1558	1	NGWA	691.3	61	1.6	288	281333	188816	47	1974-07-27	644.3	689.7	41940
68	36	Aqeb	244-1	Al' Aqeb Well K091.5	AL3452	1	NGWA	702.8	108	196.87	303	282146	188527	194	1997-06-09	508.8	505.9	54797
69	36	Aqeb	248-1	Al' Aqeb Well K093.5	AL3423	1	9	710.0	77	202.4	359	284356	188046	201	1993-11-15	509.0	507.6	38896
70	36	Aqeb	245-1	Al' Aqeb Well K094	AL1486	1	NGWA	700.0	87	171.2	320	282621	186565	171	1979-09-25	529.0	528.8	45890
71	36	Aqeb	249-1	Al' Aqeb Well K094.5	AL3004	1	NGWA	723.3	164	231	450	285167	187503	208	1989-04-02	515.3	492.3	80577
72	36	Aqeb	250-1	Al' Aqeb Well K095	AL1241	1	NGWA	730.7	104	215.4	400	285320	186908	212	1987-01-18	518.7	515.3	53654
73	36	Aqeb	256-2	Al' Aqeb Well K101-A	AL3513	1	NGWA	760.0	101	246.75	330	290468	185662	247	1998-04-02	513.0	513.3	51838
74	36	Aqeb	256-3	Al' Aqeb Well K101-B	AL3681	1	NGWA	760.0	102	0	222706	190918	0	NA	NA	NA	NA	
75	36	Aqeb	258-1	Al' Aqeb Well K102	AL1265	1	NGWA	766.1	115	244.4	400	291402	185329	244	1987-04-06	522.1	521.7	59766
76	36	Aqeb	261-1	Al' Aqeb Well K102.5	AL1273	1	NGWA	788.1	104	271.22	386	292805	184796	267	1987-06-07	521.1	516.9	54012
77	36	Aqeb	262-1	Al' Aqeb Well K103-1	AL1495	1	9	790.0	76	266.2	351	293730	184482	266	1979-10-16	524.0	523.8	39809
78	36	Aqeb	262-2	Al' Aqeb Well K103-2	AL3518	1	NGWA	790.0	98	283.4	415	293730	184487	280	1998-12-12	510.0	506.6	49735
79	36	Aqeb	263-1	Al' Aqeb Well K104	AL1225	1	NGWA	790.0	89	296	373	294563	184221	268	1986-11-08	522.0	494.0	43869
80	36	Aqeb	264-1	Al' Aqeb Well K106 A	AL1274	1	NGWA	794.8	75	276.56	407	295567	183844	276	1987-08-24	518.8	518.3	38871
81	36	Aqeb	264-2	Al' Aqeb Well K106 B	AL3517	1	NGWA	794.9	103	288.65	423	295567	183849	287	1998-11-10	507.9	506.3	52134
82	36	Aqeb	266-1	Al' Aqeb Well K107	AL2689	1	NGWA	796.6	49	282	395	297491	183068	277	1988-08-09	519.6	514.6	25099
83	36	Aqeb	267-1	Al' Aqeb Well K109	F1389	1	NGWA	790.0	77	0	299227	182541	0	NA	513.0	39501		
84	36	Aqeb	269-1	Al' Aqeb Well K110	F1333	1	NGWA	782.6	89	0	299991	182275	0	NA	513.0	45562		
85	36	Aqeb	270-1	Al' Aqeb Well K111-A	F3930	1	NGWA	780.0	71	0	300591	182075	0	NA	513.0	36340		
86	36	Aqeb	270-2	Al' Aqeb Well K111-B	F1079	1	9	780.0	90	0	300591	182080	0	NA	513.0	45934		
87	36	Aqeb	271-1	Al' Aqeb Well K112	F1312	1	NGWA	791.4	90	0	301419	181789	0	NA	513.0	46108		
88	36	Aqeb	272-1	Al' Aqeb Well K114	F1310	1	NGWA	786.6	84	0	303429	181064	0	NA	513.0	43266		
114	36	Aqeb	232-1	Al'Aqeb Well K82	AL3516	2	NGWA	650.7	0	219.8	330	274058	191807	178	1998-09-22	472.7	430.9	0

Table 6-11

Seq	WF ID	Well Field	Facility ID	Facility Name	MWI ID	Status	ROU	Contour Elev, m	Capacity nm3/hr	Dynamic Depth, m	Depth m	X	Y	Static Depth, m	Installed	Static Elev, m	Dynamic Elev, m	Q* Hdyn
115	36	Aqeb	235-1	Al'Aqeb Well K83, Kaziyeh	AL1489	2	NGWA	652.3	0	211.85	290	274643	191532	143	1990-01-20	509.3	440.5	0
137	36	Aqeb	274-1	K124 Well124-1	F 1124	1	9	826.4	60	0	312256	177894	NA	518.6	508.6	30516		
138	36	Aqeb	274-2	K124 Well124-2	F 3946	1	9	826.5	100	0	312256	177899	NA	518.6	508.6	50860		
139	36	Aqeb	277-1	K133 Well	F 3530	1	9	817.1	43	0	321849	174613	NA	518.6	508.6	21870		
140	36	Aqeb	278-1	K134 Well134-1	F 1305	1	9	810.9	42	0	322316	174471	NA	518.6	508.6	21392		
141	36	Aqeb	282-1	K140 Well140	F 3935	1	9	798.2	60	0	327919	172438	NA	518.6	508.6	30516		
195	36	Aqeb	280-1	Well K136	F 1125	1	9	801.8	42	0	323945	173895	NA	518.6	508.6	21361		
119	37	Arjan	109-1	Arjan Well No. 1	AH1000	2	1	664.7	0	313.75	545	218931	199647	299	1988-10-22	365.7	350.9	0
89	38	Bajj	237-1	Al Ba'ej Well	AL3353	2	8	680.0	0	190.6	352	276910	197061	189	1998-05-07	491.0	489.4	0
120	39	Beit Idis	81-1	Bait Idis Well	AG3006	1	2	376.8	45	236.62	495	212060	204979	235	2001-01-01	141.8	140.2	6310
122	42	Daba'an	345-1	Daba'an DP5A Well	AL3647	2	9	684.1	0	152.4	234	173090	173090	75.4	2002-06-12	608.7	531.7	0
128	43	Fo'ara	35-1	Fo'ara PS	AE1004	1	5	366.9	17	298.18	370	223066	224069	284	1986-01-06	82.9	68.7	1168
90	45	Harara	255-1	Al Harara Well	AL2709	1	9	822.4	45	304.2	362	290114	191454	304	1988-07-12	518.4	518.2	23318
130	46	Harima	29-1	Harima PS Well 1	AD3012	1	3	480.0	42	352.35	750	233059	226951	349	1995-08-18	131.0	127.7	5361
131	46	Harima	27-1	Harima Well 2	AD3016	1	3	460.0	45	348.89	726	233589	227435	346	1996-03-19	114.0	111.1	5000
132	46	Harima	25-1	Harima Well 3	AD3038	1	3	463.7	30	470	747	234252	227685	358	2000-09-11	105.7	-6.3	-188
91	47	Hodoud PS	93-1	AL Hodoud PS	AD1281	1	11	515.0	32	252.22	700	247578	219881	247	1991-03-25	268.0	262.7	8407
133	48	Jaber El Sarhan	205-1	Jaber El Sarhan Well	AD1327	2	8	580.0	0	125.62	264	262537	212878	116	1987-11-01	464.0	454.4	0
134	48	Jerash	158-1	Jerash Well 4	AL3545	2	7	580.0	0	420	234543	188071	168	1995-11-03		454.0		
135	50	Judyta	83-1	Judyta PS Well1	AB1363	1	2	320.0	95	121.18	411	214342	201946	121	1984-04-07	199.0	198.8	18888
136	50	Judyta	82-1	Judyta Well 2	AB3005	1	2	320.0	40	125.6	192	214289	202042	120	1995-05-14	200.0	194.4	7866
142	51	Khasha El Salteen	268-1	Khasha' El Salteen PS	AL3557	2	9	924.8	0	414.35	506	299880	192580	410	2000-04-15	514.8	510.4	0
143	52	Krayymeh	17-1	Krayymeh Well 1	AB1380	1	10	-158.7	50	69.2	294	207673	186608	47	1995-03-29	-205.7	-227.9	-11383
144	52	Krayymeh	19-1	Krayymeh Well 3A	AB1382	1	10	-175.0	60	65.5	225	207323	186289	11	1995-06-25	-186.0	-240.5	-14432
145	52	Krayymeh	135-1	Krayymeh Well 2	AB1361	2	10	-140.0	0	85.77	188	208095	186761	47	1985-10-29	-187.0	-225.8	0
146	52	Krayymeh	329-1	Krayymeh well 4	AB1350	1	10	-140.0	0	0	207062	188108	0	NA				
147	52	Krayymeh	329-2	Krayymeh well 5	AB1351	1	10	-140.0	0	0	207026	188166	0	NA				
148	52	Krayymeh	330-1	Krayymeh well 6	AB1377	1	10	-184.4	0	0	207561	184996	0	NA				
149	53	Kufr Khal	139-1	Kufr Khal Well	AD3060	1	7	864.6	0	0	234179	198029	0	NA				
150	54	Maghasel	144-1	Maghasel Spring	AL0630	2	7	892.5	0	0	229215	191666	0	NA				
92	55	Majar	169-1	Al Majar Well 1	AL1561	2	7	570.0	0	230.97	354	236592	186461	201	1978-11-28	369.0	339.0	0
93	55	Majar	163-1	Al Majar Well 2	AL3380	1	7	610.0	34	209	506	236681	187789	201	1996-03-20	409.0	401.0	13634
151	56	Malka	23-1	Malka Well	AE1033	2	3	460.0	0	438.47	750	220183	229297	438	1997-10-11	22.0	21.5	0
94	57	Manshiyeh	42-1	Al Manshiyeh PS 1	AB3003	1	NGWA	-26.0	100	1183	208992	218818	NA	1993-03-01	-26.0	-26.0	-2600	
95	57	Manshiyeh	41-1	Al Manshiyeh PS 2	AB1355	1	NGWA	-60.0	0	1100	208899	220467	NA	1990-04-04	-60.0	-60.0	0	
96	58	Mashare	326-1	Al Mashare`a Al Hilou well (marza`a)	AB3169	4	10	-214.9	60	64	100	205439	201064	20.68	2003-01-29	-235.6	-278.9	-16734
152	59	Mukeifteh	273-1	Mukeifteh PS Well01	F3523	1	9	920.0	40	0	306826	188886	0	NA				
153	59	Mukeifteh	273-2	Mukeifteh PS Well02	F3524	1	9	920.0	40	0	306826	188891	0	NA				
154	59	Mukeifteh	273-3	Mukeifteh PS Well03	F3761	1	9	920.0	43	0	306831	188891	0	NA				
97	60	Mukhaiba	20-1	AL Mukhaiba PS	AD1276	2	3	-63.5	0	36.38	1238	215363	234571	11	1981-07-18	-74.5	-99.9	0
98	61	Nahda	236-1	AL Nahda Well	AD3055	2	8	680.1	0	240.88	350	275049	200850	208	1999-09-21	472.1	439.2	0
99	62	Qairawan	162-3	Al Qairawan PS Spring	AL0672	1	7	572.1	98	0	234576	187794	0	NA		572.0	56024	
155	63	Qantara	126-2	Qantara PS spring	AJ0520	1	1	700.0	63	0	220070	192349	0	NA		700.0	44090	
100	64	Rafayyat	275-1	Al Rafayyat PS Well01	F3987	1	9	972.5	45	0	314084	186060	0	NA				
156	65	Rawdah Ameera Basma	240-1	Rawdah Ameera Basma Well	AL1491	1	NGWA	679.1	100	0	279749	189371	0	1998-05-07				

Table 6-11

Seq	WF ID	Well Field	Facility ID	Facility Name	MWI ID	Status	ROU	Contour Elev, m	Capacity nm3/hr	Dynamic Depth, m	Depth m	X	Y	Static Depth, m	Installed	Static Elev, m	Dynamic Elev, m	Q* Hdyn
157	66	Rawdat Bany Hashem	319-1	Rawdat Bany Hashem (Um Ramih)	AL3565	2	7	521.7	0	157.5	300	242482	181538	151.8	2002-08-14	369.9	364.2	0
101	67	Rayashi	176-1	AL Rayashi PS Well	AL2360	1	7	520.0	45	99	360	237231	184680	79	1985-08-18	441.0	421.0	18945
158	68	Sabha	257-1	Sabha & Sobheya PS	AL1493	1	9	834.6	50		400	291331	193403	305	1979-05-09			
161	70	Saham	21-1	Saham PS Well 1	AD1239	2	3	340.0	0	132.78	305	221859	234299	13	1980-08-24	327.0	207.2	0
102	72	Shajara	85-1	Al Shajara PS	AD3020	2	11	436.5	0	505	980	240937	229913	277	1995-12-09	159.5	-68.5	0
163	73	Slechat	13-1	Slechat Well 8	AB1362	1	10	-31.8	30	63.15	320	207601	192829	13	1981-11-13	-44.8	-95.0	-2850
164	73	Slechat	12-1	Slechat Spring	AB0578	1	10	14.9	30		0	207909	193028	0	NA		-150.0	-4500
165	73	Slechat	15-1	Sofarah Well (Slechat Well 3)	AB1369	1	10	-104.6	25	123.7	223	206979	189754	23.7	1988-04-17	-128.3	-228.3	-5708
166	74	Spairah	11-1	Spairah Well 1	AB3007	1	10	0.0	84	51.3	260	208275	196824	6	1991-10-20	-6.0	-51.3	-4309
167	75	Suwelmeh	198-2	Suwelmeh Well 3A	AD3040	1	8	621.5	40	305.5	590	258752	212102	205	1998-07-21	416.5	316.0	12638
168	75	Suwelmeh	201-1	Suwelmeh PS Well1	AD1262	1	8	625.1	50	173.77	385	258976	211673	170	1982-10-11	455.1	451.3	22567
169	75	Suwelmeh	198-1	Suwelmeh Well 3	AD1320	1	8	621.3	47	225.5	357	258752	212097	189	1991-10-05	432.3	395.8	18602
170	75	Suwelmeh	202-1	Suwelmeh Well 4	AD3061	2	8	610.0	0	230.65	447	259444	212127	208	2000-07-16	402.0	379.4	0
171	76	Tabaqat Fahel	347-1	Tabagat Fahel Well nr 2	AB1378	4	NGWA	-20.0	100	45.9	210	208800	207600	39.5	2002-07-25	-59.5	-65.9	-6590
173	76	Tabaqat Fahel	348-1	Tabagat Fahel Well nr3	AB1366	4	NGWA	145.0	30	195	550	209940	208050	51.1	2002-10-22	93.9	-50.0	-1499
174	76	Tabaqat Fahel	8-4	Tabagat Fahel PS & Well 3	AG3004	1	NGWA	-51.4	60		10	207974	206152	NA		-35.8	-45.8	-2748
175	76	Tabaqat Fahel	8-7	Tabagat Fahel PS & Well 1	AG3000	1	NGWA	-44.9	141	4.2	11	207973	206131	2	1998-05-09	-46.9	-49.1	-6935
176	76	Tabaqat Fahel	8-8	Tabagat Fahel PS & Well 5	AG3002	1	NGWA	-41.3	187	5.55	0	207987	206136	0	1998-07-29	-41.3	-46.9	-8776
177	76	Tabaqat Fahel	8-6	Tabagat Fahel PS & Well 6	AG3005	1	NGWA	-24.7	195	7.72	14	208019	206136	4	2001-04-23	-28.7	-32.4	-6328
178	76	Tabaqat Fahel	8-5	Tabagat Fahel PS & Well 8	AB3157	1	NGWA	-38.6	160	3.38	12	207982	206122	1	2000-04-25	-39.6	-42.0	-6699
179	76	Tabaqat Fahel	8-9	Tabagat Fahel PS & Well 9+Shboul Spring	AB0542	1	NGWA	-52.5	120		0	207944	206127	NA		-35.8	-45.8	-5496
180	77	Talat Aruz	331-1	Talat Aruz Well & PS	AL3546	1	7	504.0	20		0	231413	175917	0	NA			
181	78	Um Al Jemal	238-1	Um AL Jemal Well 1	AL1490	2	NGWA	663.7	0	157.3	290	277653	190024	142	1998-05-07	521.7	506.4	0
182	78	Um Al Jemal	241-1	Um El Jemal PS	AL3027	1	NGWA	688.5	73	182.55	375	280466	192401	173	1992-03-14	515.5	506.0	36935
183	78	Um Al Jemal	239-1	Um El Jemal Well 2	AL3563	1	NGWA	676.4	70	199.3	445	278303	193929	175	2000-08-15	501.4	477.1	33394
184	79	Um Mrara	170-1	Um Mrara Spring	AL0993	1	7	574.1	34		0	238654	185220	0	NA		574.0	19281
185	80	Wadi Al Arab	34-1	Wadi Al Arab Well 1	AE1007	1	NGWA	6.4	240		703	211976	224201		1998-05-07	1.2	-8.8	-2112
186	80	Wadi Al Arab	32-1	Wadi Al Arab Well 2	AE1008	1	NGWA	-34.8	450		407	212071	225146		1998-05-07	1.2	-8.8	-3960
187	80	Wadi Al Arab	31-1	Wadi Al Arab Well 3	AE1009	1	NGWA	-26.3	500		257	212643	225606		1998-05-07	1.2	-8.8	-4400
188	80	Wadi Al Arab	30-1	Wadi Al Arab Well 4	AE1010	1	NGWA	20.0	300		750	213312	226560		1998-05-07	1.2	-8.8	-2640
189	80	Wadi Al Arab	342-1	Wadi Al Arab Well 8	AE3005	4	NGWA	-17.9	100	15.5	243	224908	224908	3.45	2002-10-23	-21.4	-33.4	-3344
191	80	Wadi Al Arab	38-1	Wadi El Arab Well 5	AE1011	1	NGWA	60.0	310		375	212879	222570		1998-05-07	1.2	-8.8	-2728
192	80	Wadi Al Arab	39-1	Wadi El Arab Well 6	AE3001	1	NGWA	60.0	275	53.4	303	212997	22444	52	1999-10-05	8.0	6.6	1813
193	80	Wadi Al Arab	296-1	Wadi El Arab Well 7	AE1012	1	NGWA	-84.5	70	147.2	1250	211082	224966	142	1998-08-15	-226.5	-231.7	-16220
194	80	Wadi Al Arab	341-1	Wadi El Arab Well 9	AE3006	4	NGWA	63.2	100	81.38	260	212962	222313	76.1	2003-02-23	-12.9	-18.2	-1816
190	81	Wadi Ed Dear	154-1	Wadi Ed Dear Al Shargi Well 3 Well 3	AL3352	1	7	590.0	52		166	234606	188960	25	1993-10-30	565.0	590.0	30680
104	82	Waqas	298-1	Al Waqas Well	AB1356	4	NGWA	-140.0	17	112	1300	208673	216010	12	1989-09-19	-152.0	-252.0	-4284
105	83	Zamlah	259-1	AL Zamlah Well (Zamlehet Al Ameer Gazi)	AL3422	1	NGWA	779.4	52	262.31	380	292124	185033	262	1998-05-07	517.4	517.1	26937
106	84	Zatary	233-1	AL Za'tary Well 10	AL3377	1	NGWA	640.0	52	216	400	274075	185931	149	1996-04-04	491.0	424.0	22048
107	84	Zatary	228-1	AL Za'tary Well 3	AL2710	1	NGWA	650.0	53		400	273462	191502	0	NA		455.0	24169
108	84	Zatary	225-1	AL Za'tary Well 4	AL3002	1	NGWA	650.0	77	183.5	375	273250	190671	146	1992-01-14	504.0	466.5	35921
109	84	Zatary	223-1	AL Za'tary Well 5	AL3003	1	NGWA	650.0	44	186.15	386	273204	190163	144	1992-01-29	506.0	463.9	20409
110	84	Zatary	230-1	AL Za'tary Well 6	AL3463	1	NGWA	650.0	53	173.5	358	273544	190295	152	1995-12-02	498.0	476.5	25255
111	84	Zatary	224-1	AL Za'tary Well 7	AL3375	1	NGWA	641.2	47	209.7	382	273193	188641	169	1995-12-19	472.2	431.5	20280
113	84	Zatary	226-1	AL Za'tary Well 9	AL3376	1	NGWA	640.0	35	174.6	342	273393	187626	151	1996-03-25	489.0	465.4	16289

Table 6-11

Seq	WF ID	Well Field	Facility ID	Facility Name	MWI ID	Status	ROU	Contour Elev, m	Capacity nm3/hr	Dynamic Depth, m	Depth m	X	Y	Static Depth, m	Installed	Static Elev, m	Dynamic Elev, m	Q* Hdyn
197	85	Corridor	NA	Corridor Well No. 1	AL3475	1	future	787.7	100	283.09	395	294463	183473	282.29	NA	505.4	504.6	50456
198	85	Corridor	NA	Corridor Well No. 2	AL3476	1	future	732.8	115	227.40	350	293677	179577	225.4	NA	507.4	505.4	58122
199	85	Corridor	NA	Corridor Well No. 3	AL3477	1	future	715.4	130	209.10	350	293625	178511	207.6	NA	507.8	506.3	65814
200	85	Corridor	NA	Corridor Well No. 4	AL3478	1	future	750.6	115	246.20	350	293657	181511	239.8	NA	510.8	504.4	58003
201	85	Corridor	NA	Corridor Well No. 5	AL3479	1	future	700.2	115	225.30	350	293589	177512	197.4	NA	502.8	474.9	54614
202	85	Corridor	NA	Corridor Well No. 6	AL3448	1	future	689.8	125	184.10	267	292788	176830	181.9	NA	507.9	505.7	63211
203	85	Corridor	NA	Corridor Well No. 7	AL3449	1	future	686.4	130	188.30	321	291688	176589	179.3	NA	507.1	498.1	64757
204	85	Corridor	NA	Corridor Well No. 8	AL3450	1	future	680.5	130	174.75	350	291639	175612	172.6	NA	507.9	505.8	65753
205	85	Corridor	NA	Corridor Well No. 9	AL3480	1	future	667.4	125	175.70	351	291027	174870	160.4	NA	507.0	491.7	61458
206	85	Corridor	NA	Corridor Well No. 10	AL3481	1	future	667.4	95	182.60	350	292860	175171	160.4	NA	507.0	484.8	46055
86		Al Wehdeh Dam	NA	Al Wehdeh Dam	NA	4	future	80.0	4109.589	1.00	NA	NA	NA	NA	NA	79.0	324658	
Springs																		
124	27	Ain Al Fowara	124-1	Ein Al Fowara Spring	AJ0510	1	1	861.9	0	0	222143	193224	0	NA				
61	29	Ain Al Tanour	104-1	Ain Al Tanour Spring	AH0510	1	1	637.7	124	0	220345	201597	0	NA				
126	30	Ain Al Teis	333-1	Ein Al Teis Spring	AL0758	1	7	546.1	38	0	229816	186126	0	NA				
62	31	Ain Jana	122-1	Ain Jana Spring	AJ0582	1	1	830.5	12	0	222116	193359	0	NA				
63	32	Ain Rason	108-1	Ain Rason Spring	AH0506	1	1	754.4	7	0	222255	200074	0	NA				
127	33	Ain Umm Qasem	136-1	Ein Umm Qasem Spring	AK0521	1	1	213.9	9	0	213768	183656	0	NA				
116	34	Amra & Amira	253-1	Amra & Amira Well1	AL3018	1	9	749.5	47	343	286068	191280	233	1991-11-24				
117	34	Amra & Amira	253-2	Amra & Amira Well2	AL3019	1	9	749.6	43	289.45	346	286068	191285	289	1992-06-16			

NA= Information not available or not applicable

6.10 Economical Velocities in Force Mains

In the comparison of alternatives to supply local reservoirs from the transmission system, it is frequently necessary to select the sizes of force mains, which carry the flow from a transmission pump station to a reservoir. This will be done based on the approach of "economical velocities", in which the selected pipe size provides the best balance between the cost of the pipe and the present-worth cost of power attributable to pipe friction. The derivation of the economical velocity and preliminary results are given in **Appendix E**.

Typically, pipelines in pumped transmission systems are designed for peak velocities in the vicinity of 1 m/s. The results obtained in **Appendix E** confirm this result, and provide some amplification on the conditions under which the design velocity may go above or below this value. As shown in **Figures 6-5** and **6-6**, for a given pipe size, there are 3 flow values of interest:

- An "optimal flow" at a peak design velocity in the range of 0.9 to 1.0 m/s, at which the flow and diameter provide an optimal match to each other;
- A "maximum flow" (for which the peak design velocity is in the range of 1.0 to 1.2 m/s) at which the cost of the pipe and power matches that of the next-larger standard pipe size; and
- A "minimum flow" (for which the peak design velocity is in the range of 0.6 to 0.8 m/s) at which the cost matches that of the next-smaller standard pipe size.,

For pipe sizes selected to carry a peak flow of 1.2 times the average flow, the velocity at the average flow falls within a relatively narrow range close to 0.8 m/s.

Figure 6-5 Economical Velocities in Force Mains

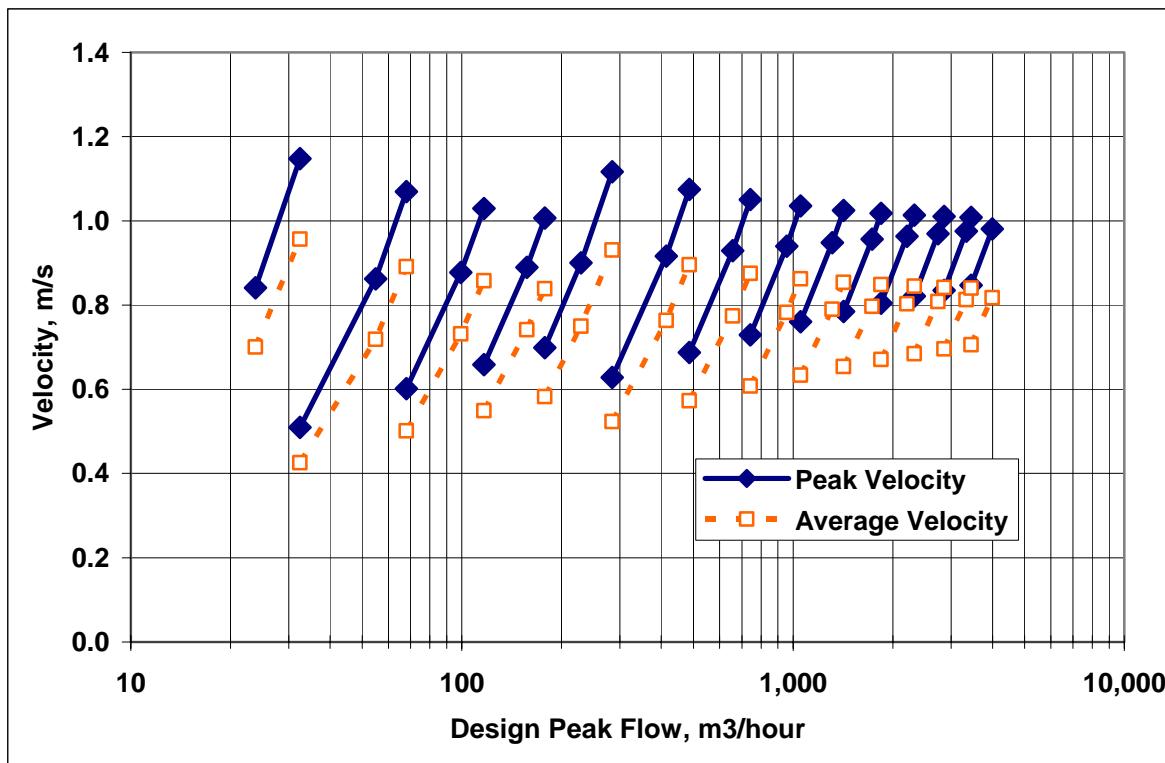


Figure 6-6 Economical Pipe Diameters

